A systematic review of confounders effecting on Sudden Infant Death Syndrome (SIDS)

Abstract

Sudden Infant Death Syndrome (SIDS) is still the primary cause of mortality which is not only causing deaths in rich countries but also in all over the world. Many confounders are responsible for SIDS, which still can be avoided, and the prevalence can stop to save infant deaths. The present systematic review has been conducted to distinguish those responsible factors. The objective of the current systematic review was to identify those confounders and corelate them with SIDS. For conducting the current systematic review, the basic online scientific data bases i.e., (Scopus, ProQuest, Science-Direct, Web of Science along with PubMed) were utilized for searching along with the manual research on Google Scholar. The present systematic review was in line with 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards and recommendations. A 20-point appraisal tool for Cross-Sectional Studies (AXIS tool) was used to critically evaluate the quality of the used studies. Additionally, applying the framework of PECO-S (Population -Exposure -Comparison -Outcome -Study design) numerous observational studies were enrolled for this review. Out of 1989 studies obtained, 24 studies fulfill the inclusion criteria and are thus included in the present review. The original research studies included in the present systematic review were all in "English" language published during the time duration of 2015-2023. Overall, 24 research papers covering 11 different countries' sample population were included. More number of infants died due to SIDS in the age group of 2-4 months. The average number of males infants were 74.8% with SIDS in current study. Smoking of parents contributed around 64.3%, low income about 56.9%, sharing of beds contributed around 58.7%, whereas non-breastfeeding contributed more than 90% in SIDS in infants. The main causative confounders are the breast feeding, smoking of parents, low-income status of parents and maternal education.

Keywords: Sudden Infant Death Syndrome (SIDS), confounders, factors, infants, parents, deaths, maternal education, PRISMA, AXIX tool.

1. Introduction

Globally, one of the major reasons for sudden death of 1 month- 1 year old infants is Sudden Infant Death Syndrome (SIDS) (1). If sudden unanticipated death of the baby is instantaneous and unexplained as the result of death investigation, medical examination and clinical history evaluation, then it is concluded as death due to SIDS (2). The other name of SID is sudden impenetrable death because usually the death is related with night sleep of the infant (3). Generally, this syndrome occurs during infant's night sleep, without any definite indication or symptom, due to which it become impossible to clinically manage it beforehand (4).

In the United States, prime reason of infant's death and neonates is SIDS (5). Majority of the cases of SIDS report that around 90% of SIDS occur around 1-6 months age of infants, However the average age for highest risk is from 1-4 months of infant age (6).

The most important fact about SIDS is that in majority of the cases, the infant seems quite healthy before their death (7). Around 2300 infants die in the United States every year, approximately (6). Another astonishing fact about SIDS is that it is more common in infant boys as compared to infant girls, moreover comparatively more deaths occur during winter season and early spring season (8).

Multiple studies have presented interventions to reduce SIDS death in the US, proposing that sleeping environment of infant should be closely monitored moreover, infants should sleep on their back and avoid sleeping with face covered with blanket or stuff toys (9).

In the present age, the definite trigger factor of SIDS in unidentified (6). The major confounder and risk factors of SIDS are sleeping face down or on their side and bedsharing (10). As the result of bedsharing or sleeping with their face covered by blanket, the re-breathing of expired gases results in hypercapnia and hypoxia (11). However, the other contributing factors include; soft fluffy mattress of infant, luxurious bedding, sleeping with stuff toys or pillows, as they form slight air pocket around mouth of infant which can sum up the exhaled air, that contains high level of carbon dioxide (12). Afterwards, when they re-breathe that exhaled air, the amount of carbon dioxide in their blood stream increases and the level of oxygen falls down which leads to SIDS in infants (9). Furthermore, a few reported cases of SIDS deaths concluded that it was due

to the family history of patients with SIDS, which indicates that there could be the genetic linkage in etiology of SIDS (13). Another contributing factor include carelessness from parents regarding diet of infant and providing protected environment (2,14). Moreover, the age of mother being less than 20 years, low weight of infant at birth or premature baby as well as mother utilization of alcohol or smoking during the tenure of pregnancy are other contributing predictors for SIDS(15).

Around the world, multiple confounders of SIDS have been studied and observed but majority of them have not been well explained till date. The available literature of SIDS confounders is scattered and disintegrated. Although the available literature has reported various confounders of SIDS but still the information is not available in concise form where anyone can quickly go through the factors responsible for SIDS. The literature should be available in an integrated manner to everyone to reduce the prevalence and occurrence of SIDS.

After a detailed and critical evaluation of available literature on SIDS all over the world, up to the best of our knowledge, we have concluded that the details of confounders affecting SIDS have not been observed as a high precedence and have been constantly and significantly ignored.

There is no proper justified reason available for not studying and compiling these confounders of SIDS which is a major and alarming pediatric health issue all over the world.

The present systematic review is conducted to fulfill the gap in literature about the confounders of SIDS all over the world. The main objective of current study is to find and compile all available studies with known and assumed risk confounders which have any direct or indirect effect on SIDS.

2. Materials and Methods

2.1 Study design

The current systematic review has been carried out as per standards and criteria set bythe Cochrane Handbook for Systematic Reviews. Moreover, current study is also in line with the procedures and protocols set by PRISMA flow statement guidelines. The major keywords used to find different studies on confounders were included ‘sudden infant death syndrome (SIDS)’,

'factors affecting on sudden infant death syndrome', 'risk factors for SIDS', 'confounders of SIDS', 'predictors of SIDS', 'components', 'points, effects', 'the features', 'elements of SIDS'. Different online electronic databases were utilized for this systematic review. Those electronic databases were Science Direct, ProQuest, Scopus, Web of Science and PubMed. Utilizing the framework of PECO-S (Population, Exposure, Comparison, Outcome, Study design) multiple cross sectional (observational) studies has been shortlisted. The recruited research studies were critically evaluated for the quality. Appraisal tool for Cross-Sectional Studies (AXIS tool) was used. This tool got AXIS 20 points critical appraisal criterion for checking the quality of cross-sectional observational studies (16). All the scientific research has been confined to English language only as of international language. And the SIDS related required articles which were published in last nine years (2015-2023) only as of recent and updated research only. The data was depicted and tabulated as narrative-review. Among 1989 studies acquired, 25 studies meeting the inclusion criteria has been recruited in the present review.

2.2 Inclusion criteria

The inclusion criteria for the present study was well defined and was as follows:

1) The inclusion studies all contain major or minor objective as determinants affecting SIDS all over the globe.

2) The studies were from all over the world not from any specific regions.

3) All included studies were original research papers published in well reputed journals on SIDS.

4) All included studies were published in English language only, as an international language and easy to understand for the future readers.

2.3 Exclusion criteria

The exclusion criterion for the present study was well defined and was as follows:

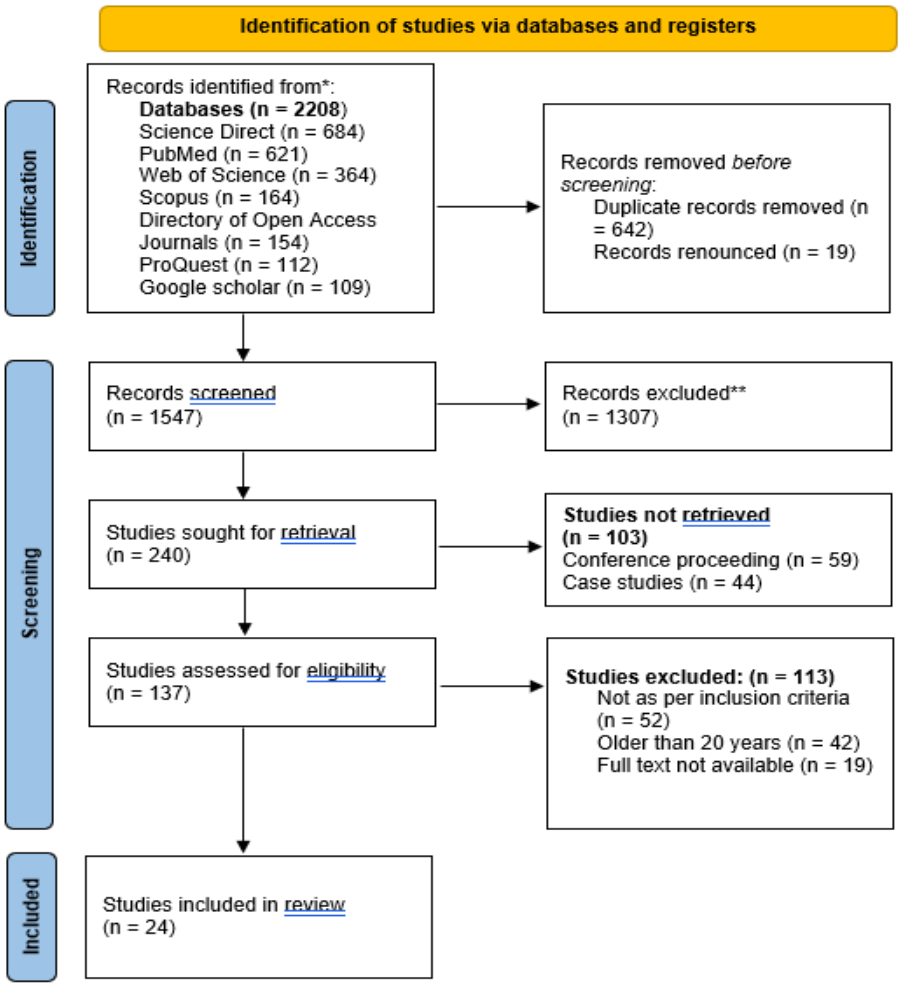
1) The studies with prevalence and its factors affecting were excluded from the current study as it was not the objective.

2) Case studies, reports submitted to any organization, or any degree thesis submitted to any university.

3) The original research article officially published in language other than English.

2.4. Data extraction

The data which was shortlisted from research studies included: sudden infant death syndrome (SIDS), factors affecting on sudden infant death syndrome, risk factors for SIDS, confounders of SIDS, predictors of SIDS, components, points, effects, the features, elements of SIDS. To avoid the risk of biasness, "Cochrane Bias" tool of LvE for risk assessment has been used. This risk of biasness estimation was additionally verified by HdG, KT and LvD.



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For more information, visit: http://www.prisma-statement.org/

Figure 1: PRISMA flow diagram for systematic review

2.5. Data synthesis and analysis

The confounders effecting on SIDS was retrieved in all the included research studies shortlisted for the current systematic review. Furthermore, the predictor, factors responsible for the deaths in SIDS either direct or indirect effecting on it were also investigated in all included studies. The results were assessed and then accumulated in the present systematic review.

3. Results

As per the selection criteria, 2208 original research studies has been shortlisted by various electronic database searches, out of which 1547 research articles has been screened after eliminating duplicate records. Out of those1547 shortlisted studies, 1307 studies were eliminated that did not tally the required keywords, whereby 240 studies were shortlisted. Among those another the 103 shortlisted research articles, some studies when searched for full text version were found to be the conference proceedings and case reports that were published in special edition of journals and were not accessible as full text. The full text of 137 was not available to double check with the inclusion criteria, moreover from them also total of 113 studies were again leftover due to not meeting the inclusion criteria fully, older than 20 years and full text not available reasons. Afterwards, 24 research articles were shortlisted that were in accordance with the inclusion criteria and were accessed for the current review. The details are depicted in PRISMA flow diagram (Figure 1).

Among 24 included studies, only one study was published in 2021. The majority of the studies published in the year 2022 and 2013 (4 studies each year) were published. The aims of included studies were clearly defined. While most of the studies recruited in this review have appropriate study design and adequate sample size. Findings of the recruited articles were defined and consistent. Most of the included studies had not taken any measures to address the non-responders as many of the included studies were having retrospective kind of study design. Moreover, all the included in this review had clearly stated objectives (Table 1,AXIS tool).

Similarly, all the included studies had ethical approval together with consent of participants.as mentioned in (Table 1, AXIS tool).

Study origin (research country), time interval of data collection, study design, sample size calculation of study subjects, confounders included effects of confounders as well as the major outcome of these studies are mentioned in Table 2.

Among the recruited original research studies from all over the globe, eight of the included studies were from USA. All of the included studies had an aim of finding out the different confounders having any positive or negative impact on SIDS. Only one study belongs to Müller-Nordhorn et al. 2015 reported the impact of Diphtheria-tetanus-pertussis (DTP) on SIDS (study 23). On the other hand, only two studies belonged to Hwang et al. and Litchfield et al reported about the effect of air pollutants on occurrence of SIDS (Table 2).

Study 20 and 24 belonged to Jhun *et al*. 2017 and Auger *et al.* 2015 respectively, were studies that reported the impact of weather change in the form of change in temperature with the impact on SIDS (Table 2)

Table 1: Appraisal tool for Cross-Sectional Studies (AXIS tool)

	Study 1 (17)	Study 2 (18)	Study 3 (19)	Study 4 (20)	Study 5 (21)	Study 6 (22)	Study 7 (23)	Study 8 (24)	Study 9 (25)	Study 10 (26)	Study 11 (27)	Study 12 (28)	Study 13 (29)	Study 14 (30)	Study 15 (31)	Study 16 (32)	Study 17 (33)	Study 18 (34)	Study 19 (35)	Study 20 (36)	Study 21 (37)	Study 22 (38)	Study 23 (39)	Study 24 (40)
Introduction																								
Were the aims/objectives of the study clear?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Methods																								
Was the study design appropriate for the stated aim(s)?	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was the sample size justified?	✓	✓	✕	✕	✓	✕	✕	✕	✕	✕	✓	✕	✓	✕	✓	✓	✓	✓	✓	✓	✕	✕	✕	✓
Was the target/reference population clearly defined?	✓	✓	✓	✓	✓	✓	✓	✕	✕	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✕	✕
Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?	✓	✓	✕	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✕	✓	✕
Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation?	✕	✓	✕	✓	✓	✓	✕	✕	✕	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✕	✕
Were measures undertaken to address and categorize non-responders?	✕	✕	✕	✕	✓	✕	✓	✕	✕	✕	✕	✕	✕	✕	✕	✓	✓	✓	✕	✕	✓	✓	✕	✕
Were the risk factor and outcome variables measured appropriate to the aims of the study?	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓	✓	✕	✓	✓	✓
Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialed, piloted or published previously?	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Is it clear what was used to determine statistical significance and/or precision estimates? (e.g., p-values, confidence intervals)	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓	✓
Were the methods (including statistical methods) sufficiently described to enable them to be repeated?	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Results																								
Were the basic data adequately described?	✓	✕	✓	✓	✓	✓	✕	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓	✕	✓	✓
Does the response rate raise concerns about non-response bias?	✓	✓	✓	✕	✓	✕	✓	✕	✕	✕	✕	✕	✓	✓	✕	✓	✓	✓	✕	✕	✕	✓	✓	✓
If appropriate, was information about non-responders described?	✕	✕	✓	✕	✓	✓	✓	✕	✕	✕	✕	✓	✓	✕	✓	✓	✓	✕	✕	✕	✓	✓	✓	✓
Were the results internally consistent?	✕	✓	✕	✓	✓	✕	✓	✕	✕	✕	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were the results presented for all the analyses described in the methods?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓
Discussion																								
Were the authors' discussions and conclusions justified by the results?	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓
Were the limitations of the study discussed?	✓	✓	✕	✓	✓	✓	✓	✓	✓	✓	✕	✕	✓	✕	✕	✓	✕	✓	✓	✕	✕	✕	✓	✓
Other																								
Were there any funding sources or conflicts of interest that may affect the authors' interpretation of the results?	✕	✓	✓	✓	✕	✓	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✕	✓	✓	✓	✓	✓	✕
Was ethical approval or consent of participants attained?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✕

Table 2: Study characteristics of the included studies

Sr. No.	Study author and year	Country	Study design	Study population and Sample size (N)	Study aims	Confounders studied	Result and conclusion	Recommendation
1.	Osei-Poku et al. 2023 (17)	Zambia	Qualitative assessment	FGDs - Focus group discussions conducted with 35 mothers	To find infant sleep habits along with additional risk elements of SIDS	Awareness about SIDS, Infant sleeping position and posture, Room and bed sharing, Sleeping surface as well as parental smoking	Side sleeping position seemed to be safer for the infant in SIDS, breastfeeding along with infant care and monitoring was also considered as major factor for SIDS. More female (54.3%) infants died due to SIDS. Maximum number of infants (37.1%) died in age of 2-4 months	Mothers' education and training should be given by health care providers and cultural beliefs should also be needed to address by medical professions
2.	Glinge et al.2023 (18)	Denmark	Register-based cohort study	2384 siblings of infants who died of SIDS.	To find out risk factors of SIDS in siblings of infants who died with SIDS	Genetic factors and mother education	Genetic factors contributed to a 4 times greater risk for SIDS and mother education had direct relation with SIDS. More number of male (51%) infants died due to SIDS; maternal education less than primary was observed as 54% of the total sample size.	Clinicians need to provide counselling and future recommendations to stop the future incidence of SIDS in family
3.	Parks et al. 2023 (19)	Georgia	Case-control study	2060 respondents from centers of Disease Control & Prevention data	Finding out relationship between unsafe infant sleep practices and SIDS	Suffocation, maternal age, infant gender, and Maternal smoking	Significant association was observed with suffocation and SIDS. More number of male infants (60.7%) dies due to suffocation. Mean material age with maximum number of died infants was 20-24 years.	Similar kinds of studies need to be conducted all over the world to see more association about it.
4.	Gunnerbeck et al. 2023 (20)	Sweden	A National register study	2,061,514 infants throughout the country with data on tobacco exposure during early months of pregnancy	Finding the relationship of nicotine along with Swedish snuff use during pregnancy with higher risk of SIDS	Smoking and snuff use	Snuff usage in mothers was directly related with the raised risks of SIDS. The maximum number of infant deaths (30.5%) were belonged to mothers with the mean age of 25-29 years. The maximum number of heavy smoking mothers (40.4%) got years of education only less than 9 years.	Nicotine in any forms should be prevented during pregnancy period to avoid SIDS.
5.	Polavarapu et al 2022 (21)	USA	Case-control study	533 respondents of parents and maternal pediatric medical records	To develop new SIDS risk scoring system for predict the risk of SIDS	Breast feeding duration, Paternal smoking, and maternal age	Longer period of breast feeding resulted in less cases of SIDS, Paternal smoking, and maternal age also directly related with SIDS (OR = 13.85, $p < 0.001$). The maximum number of infants died (91.49%) due to SIDS had breastfeeding only less than two months	By using national or international dataset this kind of risk scoring system can be finalized for physicians and their patients to avoid chance of SIDS in future

6.	Ouattara et al. 2022 (22)	USA	A National register study	2280 parents maternal medical records	To find out the relationship of sleep positions with SIDS	Sleep practices and sleep positions	Strong association was observed between the sleeping position on stomach and SIDS.	Parents should be counseled about the sleeping positions by health care providers
7.	Hegyi et al. 2022 (23)	USA	Case-control stud	250 records of death taken from national register	To find out the relationship of age with SIDS	Age especially during first one of age	The first week and the first month of age is rarely responsible for SIDS	Similar studies need to conduct throughout the world to find the relation
8.	Yamada et al. 2021 (24)	USA	Case-control study	Record of all thecohort of SIDS deaths taken from 2007 to 2016	To find out relationship of SIDS death with different factors	Race, the gestational age, Infant's birth weight, education status of mothers, smoking along with history of child deaths	Male children are on more risk of SIDS ($p < 0.01$, OR = 0.80 with females) Black maternal race, less education of mothers along with reduced birth weight promotes high risk for SIDS.	Healthcare providers need to provide counselling and proper recommendations to stop the incidence of SDIS
9.	Oliveira et al. 2020 (25)	Brazil	Retrospective cohort study	63 children aided from January-December; 2016 in nursing consultations	To find out the risk elements of SIDS during nursing consultation	Risk elements distinguished were; soft stuff toys, bed sharing, breastfeeding, and immunization	The average infant's age recorded was 3.2 months. The presence of soft toys related to SIDS was 93.6% and breastfeeding was about 95.2%. Mother's age, single parent family, less mother education (93.7%),males (90.6%), less family income are directly on risk for SIDS	Nursing educational interventions and proper recommendations are needed to stop the incidence of SDIS
10.	Shipstone et al. 2020 (26)	Australia	Retrospective cohort study	Hospital records from 2010-2014 evaluated who got exposure to SUDI	To find out the effects of risk factors on SIDS occurrence	Infant age, socio-economic status, smoking, family type and Infant sleep position	Socio-economic conditions of living infant 52.5% (OR = 6.93, 95% CI = 2.20, 21.86), and sleep position are directly on risk for SIDS. Smoking of parents is having maximum effect of 75.0%.	Cross sectional studies are needed to find out the current status of SIDS in population.
11.	Lavista Ferres et al. 2020 (27)	USA	Retrospective cross-sectional study	Record of 2003 to 2013 was accessed and 37 624 deaths were found of infants with SIDS	To find out relationship of SIDS death with age	Infant age and mother age	A greater number of SIDS were observed from the age less than 3 months 77.3%, more deaths (69.4%) were there where the mother age was from 25-29 years.	These underlying causes of deaths can be further studied to know mechanistic understanding of causative factors of SIDS.
12.	Osawa et al. 2020 (28)	Japan	Retrospective study	Record of 259 for SIDS case were identified and analyzed	To find out the recent course of conditions along with risk factors for SIDS	Age, birth weight, mother age, sleeping position and mother smoking habits	More death rate in children at age: 1 month (18%) and in six months (72%), more deaths occurred when infant weight was less ($p < 0.01$, OR = 2.0), younger age mothers have more cases of SIDS. Co-sleeping was recorded for 61%.	Negligence of parents should be properly addressed to decrease the prevalence of SIDS

13.	Anderson et al. 2019 (29)	USA	Retrospective cross-sectional study	Death data records for births between 2007 and 2011	To find out the effects mother smoking on SIDS	Smoking of mothers	Smoking during pregnancy can result in raised risk factor for SIDS up to twofold (AOR = 2.44, 95% CI = 2.31–2.57).	There is a need for smoking cessation before pregnancy to avoid the case of SIDS
14.	Hwang et al. 2019 (30)	Korea	Case-crossover study	454 death cases in Korea due to SIDS	To find out risk factor of SIDS in association to contact with atmospheric pollution	Air pollutants	A rise in NO_2 (AOR=5.12, 95% CI: 1.27–20.63) & CO amounts was linked with enhanced risk for SIDS in Korea. More number of infants (60.8 %) died in the age of 3-11 five months due to SIDS.	Health policies should be changed for betterment of air quality to safeguard infants and decrease cases of SIDS
15.	Litchfieldet al. 2018 (31)	UK	Case-crossover study	211 SIDS events	To find out association among short-term differences in air pollutants and incidence of SIDS	Air pollutants	Air pollutant particles, specifically PM_{10} along with NO_2, might present a relation with raised SIDS	Further studies are suggested to distinguish probable routine explanations regarding the input of air pollution upon SIDS
16.	MacFarlane et al. 2018 (32)	New Zealand	Prospective case–control study	786 (137 cases and 649 controls)	To find out the relationship betweenbed sharing and smoking with SIDS	Bed sharing and smoking	Risk elements include; sharing of bed and smoking during pregnancy had a strong association with SIDS (AOR = 11.20, 95% CI = 3.46, 36.29). Smoking during pregnancy was 46.7%.	Smoking in any forms should be prevented during pregnancy period to avoid SIDS
17.	Friedmann et al. 2017 (33)	USA	Population-based cohort study	Consisted of total 4,007,105 births with total of 24,174 deaths of infants	To find out maternal risk elements related with SIDS	Race, mother smoking, premature birth	Maternal smoking (OR = 3.56, 95% CI = 3.18–3.99) a smoking of mother, OR = 2.48, 95% CI = 2.16–2.83) was the biggest prenatal modifiable risk element pf SIDS.	Persistence of Public Health programs will ensure protected infant sleeping habits and smoking cessation required through the pregnancy tenure.
18.	Mitchell et al. 2017 (34)	New Zealand	Three-year nationwide case-control	303 SIDS cases in three years	To find out major risk factors for SIDS	Smoking of mother and sharing of bed	The mixture of mother smoking throughout pregnancy (74.2%) and infant's bed sharing with parents (57.7%), male gender of infants (57.9%) is particularly dangerous for infants with SIDS.	Mortality could be reduced up to 70% after addressing these two issues
19.	Son et al. 2017 (35)	Korea	Nationwide retrospective cohort study	8,209,836 SIDS cases from record	To find out risk factors for SUDI	Parents' age, birth weight, gestational age	Inequalities living conditions and bed-sharing situation causes SIDS	Parents who have lower educated and economic condition should be properly compensated in making of health policies.

20.	Jhunet al. 2017 (36)	USA	Nationwide retrospective study	60,364 SIDS cases	To find out relationship between ambient temperature and SIDS	Winter and summer temperature risks	More deaths were observed in summer (16.9% more) as compared with winter season in different parts of USA	Healthcare providers should educate papulation about heat waves related to climate change and its relationship with SIDS.
21.	Hamadneh et al. 2016 (37)	Jordan	Cross sectional study	604 mothers	To find out the main risk factors related with SIDS	Infant head covering,blankets, and co-bedding	Perilous sleeping habits of infants and unsafe environment confounders are responsible for SIDS in infant deaths.Infant head covering was 84%, heavy bedding 81%, blankets 67%, and co-bedding 66% responsible for the Infant deaths. Low economic condition of parents was responsible up to 53% for the death of infants with SIDS.	Awareness should be given to the general population by health care providers.
22.	Joanna Garstang et al. 2016 (38)	UK	Mixed-methods study	113 eligible families	To find out role of modifiable risk factors for SIDS	Self-blaming, Responsibility not blame	Most of the parents were Self-blaming for not taking care of infants with SIDS. The unsafe sleeping environment factor was responsible 11 out of 12 points, whereas parents smoking got 7 out of 12 points.	Health care professionals should describe the risk factors for SIDS.
23.	Müller-Nordhorn et al. 2015 (39)	Germany	Nationwide retrospective study	All records of Centers for Disease Control and Prevention from 1968 to 2009	To find out relation among diphtheria tetanus pertussis (DTP) immunization with SIDS over time	Diphtheria-tetanus-pertussis (DTP)	Increased DTP immunization is directly associated with decreased about 10% cases of SIDS mortality.	Timely DTP immunization should be emphasized.
24.	Auger et al. 2015 (40)	Canada	Case crossover study	196 certified case reports of SIDS, with inclusion of 89 infant deaths at 1 to 2 months. 94 infant deaths at 3 to 12 months.	To find out the relationship of circling heat and SID	Change in higher temperatures with SIDS	Strong association was observed in raised circling temperature and SIDS specially at age ≥ 3 months.This relationship was stronger for infants of age 3 to 12 months as compared to infants of age 1 to 2 months (OR = 3.90, 95% CI: 1.87, 8.13 and OR = 1.73 95% CI: 0.80, 3.73)	Strategies for global warming in future, including climate and medical alerts during heat waves should be there to avoid the risk of SIDS

4. Discussion

After increasing the prevalence of SIDS all over the world, healthcare providers from different countries are trying to look for an available solution to avoid the spread of SIDS (21,41). Although there are different studies available to find out the factors that have a direct correlation with SIDS all over the world (9,18,26,42,43), still there is a need to combine all the factors in the same place so that the populations all over the world in a simple word can understand what different confounders are directly related to SIDS and thus can save the life of infants. Although different original research papers are available to report the different confounders affecting SIDS all over the world (1,36,44,45), still there is no reason to believe why the general population don't have a proper understanding of the confounders responsible for SIDS and can save the life of different infants all over the world. Although there are different studies available all over the world from different countries and they reported factors affecting SIDS there is no single study available to combine all these factors together in one place and can report or recommendations for future readers and especially for the general public (5,18,23,29,43). Thus, our study will be the kind of novel study in which there was no similar kind of study available all over the world which can report these responsible confounders belonging to SIDS to the general public as well as to the future researchers. In support of this argument current study will not only find out the factors responsible for SIDS in poor or rich countries but together we collected from all over the globe.

The American Academy of Paediatrics (AAP) urges that infants be positioned while sleeping on the supine position (46), but still different studies resulted that the infect deaths were due to the sleep position (3,26,44,46–48). Side sleeping position seemed to be safer for the infant in SIDS as reported by Osei-Poku et al. 2023, Ouattara et al. 2022 and Shipstone et al. 2020 in this review study (17,22,49), these findings are quite similar and supported with the findings of a study conducted in USA in 2016 which reported that the infants who shared the beds with their caregivers the chances of getting SIDS is only 2.7% to 21.5%. These findings are quite different from the rate reported by someone elsewhere in the USA, where the percentage was 77% (50). Similarly, while sleeping covering of infants with a blanket or other soft toys also can contribute to SIDS around 84% as reported by an included study in this review by Hamadneh et al. 2016 (37), but these findings of our included study is quite different from a study reported somewhere

else when they were finding out the reasons of SIDS and they reported that this would not be the reason behind for death of infants (51).

The child age confounder is another factor that was well studied by this review and mean age reported was 2-4 months when SIDS was there for infants (17,25,27,40). These findings are in line with another review conducted in past while studying the reasons for SIDS in infants where the infant age was less than 3 months at the time of SIDS death (9). Whereas these findings are quite different from another included study in this review, which reported the infant age was from 3 to 11 months at the time of death due to SIDS (30). On the other hand, another included study by Auger et al reported that the number of infant deaths is more when they are from 3 to 12 months old as compared to the age of 1 to 2 months (40). The age of mothers is also considered important while we consider the age of infants over here in this review. Two included studies reported that the mother age was from 20 to 24 years when their infants died of SIDS (19,28), whereas another two studies included in current review reported that the age of mothers was from 25 to 29 years (20,27).

The gender of infant is another important aspect studied by this research. Glinge et al, Yamada et al, Oliveira et al, Mitchell et al reported that more number of male infants are died due to SIDS (18,24,25,34), while their results are totally different from the study conducted by Osei-Poku et al which reported that overall more female infants died due to SIDS (17). We also found impact of mother smoking with SIDS as parent smoking is another contributing factor for increase prevalence of SIDS in all over the world. Two included studies in this review by Gunnerbeck et al and MacFarlane et al presented that smoking mothers whose infants died due to SIDS was around 40% (20,52), whereas these findings are different from another included study in this review by Mitchell et al according to which this percentage was about 74.2%. There is another study conducted by someone else reported that the smoking percentage during pregnancy for the females was only 7.5% but this percentage could be double for those female whose infants was died due to SIDS (29). The difference in percentages belonged to both study groups are probably due to the difference in sample size and population involved in both study groups.

Another causative agent behind the pathogenesis of SIDS can be an income of parents whose infants got SIDS. Evidences in the past suggested that income is directly or indirectly associated with SIDS in all over the world (12). An included study conducted in Brazil in 2020 by Oliveira et al in 2020 proved that the less family income was the factor behind the death of infants due to

SIDS and the percentages of death was 57.3% (25). On the other hand, the results of a study conducted by Hamadneh et al in 2016 in Jordan stated that low income condition of parents was responsible up to 53% for the death of infants with SIDS (37). Both of these studies clearly stated that there is a need for an investigation in detail about the impact of socioeconomic status on SIDS in future. However, there are different studies available which proved that there is no relation of low income of parents with SIDS but there are other factors responsible for the deaths of infants thus it is clear low-income status is not a direct related factor affecting on SIDS.

In current systematic review we also conducted impact of another risk factor of breastfeeding in relation to the SIDS. While in the past it was stated that there is no relation of breastfeeding with SIDS deaths findings of our systematic review is bit different then the past review (44). As per the results of our included studies it is well stated that breastfeeding to infants can save up to the mean of 90% SIDS deaths in infants (17,21,25). Furthermore, study conducted in Zambia stated that breastfeeding and monitoring of infants was considered as a major factor for SIDS. They emphasize not only the breastfeeding but together with the monitoring of infants can save the lives of infants (17). Similarly, mother education is another contributing confounder for SIDS which is also studied by current review. A study conducted in Denmark stated that the total percentage of deaths associated with SIDS was 54% because of less educated mothers (18), whereas this percentage was 91.49% when the study was conducted in USA (21), similarly another study conducted in Brazil also stated that the mother's less education responsible for the death due to SIDS was 93.7% (25). Thus, it is proven that mother education is directly responsible for the saving of the lives of infants.

Another confounder studied by the current review was the air pollutants responsible for SIDS. A study performed in Korea which was included in current review proved that the the production of carbon monoxide and nitrogen peroxide in the night is directly responsible for the higher risks of SIDS in Korea (30). Probably when the kids are sleeping, their parents are due to low temperature wanted to cover their kids with a blanket and thus the production of gases starts out with the human body and the kids are inhaling the same gases that could be the main causative agent for SIDS. The same mechanism was also reported by a study conducted in the UK in 2018 where the air pollutants are nitrogen peroxide and PM_{10} (31).

Another confounder studied was Diphtheria-tetanus-pertussis (DTP) for SIDS. Only one study was found in Germany which was conducted in 2015 and was included in present systematic

review. According to which increase the DTP immunization is directly associated with decreased about 10% chances of SIDS mortality (39). Last but not least the confounder study for the present systematic review was the temperature changes due to which SIDS mortality is getting affected. Asbury conducted in USA in 2017 by Jhun et al according to which more deaths were observed in summer as compared to winter season in different parts of USA (36). Similarly, a study conducted in Canada in 2015 by Auger et al according to which there was a strong association observed between temperature and SIDS. This relationship was more stronger in infants from the age of three months to 12 months as compared to the infants from one month to two-month of age (40). The relationship of high temperature with SIDS is established by our systematic review but still needed a bigger clinical trial which can be performed in future to further access the association among high temperature and deaths of infants due to SIDS.

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